



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

SCIENCE

FRIDAY, AUGUST 14, 1914

THE NEEDS OF RESEARCH¹

CONTENTS

The Marine Biological Laboratory:—

The Needs of Research: DR. R. S. WOOD-
WARD 217

*Addresses at the Dedication of the New
Buildings:* DR. R. S. LILLIE; DR. HUGH M.
SMITH 229

*Time Ratios in the Evolution of Mammalian
Phyla:* DR. W. D. MATTHEW 232

Scientific Notes and News 235

University and Educational News 239

Discussion and Correspondence:—

Young Whitefish in Lake Superior: T. L.
HANKINSON. *The Poor Hatching of Nor-
mal Eggs:* T. D. BECKWITH, G. D. HORTON.
*Heterodera radicola attacking the Canada
Thistle:* L. E. MELCHERS. *An Avalanche
of Rocks:* DR. EDWARD S. MORSE..... 239

Scientific Books:—

*Bateson on Problems of Genetics, Weis-
mann's Vorträge über Deszendenztheorie
and Bateson's Principles of Heredity:* PRO-
FESSOR W. E. CASTLE 241

Special Articles:—

*A New Method for the Determination of Soil
Acidity:* E. TRUOG. *Experimental Efforts to
retain the Freshness in Cut Rose Blooms:*
F. R. PEMBER 246

THE occasion which brings us together to-day is one of profound moment alike to biologists and to the devotees of other branches of science; for in the dedication of your new laboratory we make distinct and formal recognition at once of our existence in a universe chiefly unknown to us and of the most effective method thus far devised for interpreting it. This universe is the complex of phenomena in which we find ourselves and of which we humans form a part, and this method is the method of research. The evolution of our race may be summed up under the two heads of man's relations to and of his means of investigating this complex of phenomena in which he plays the rôle usually of a nameless supernumerary, but occasionally also the rôle of interpreter, or even manager, in an ephemeral presentation of some aspects of the larger drama of life. The event we celebrate, therefore, should stimulate our keenest philosophic interest and rouse our enthusiastic admiration for the favoring circumstances which have made it possible to secure this substantial adjunct to the rare opportunities which have long made Woods Hole a resort for students and investigators in biological science. This event means progress; it marks a definite step in advance along lines of proved advantage to society at large; and it makes additional steps forward easier not only for your organization, but for all similar organizations. Moreover, the age in which we live is preeminently an age of restless, if not

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

¹ Address read on the occasion of the dedication of the Marine Biological Laboratory, Woods Hole, Massachusetts, July 10, 1914.

impetuous, enquiry, and the development of establishments through which research may be pursued patiently and systematically to demonstrable conclusions is one of the most inspiring signs of our times as well as one of the most essential agencies for the conservation of the best interests of community and national life.

For without the aid of such establishments it is not evident how we may distinguish what is fundamental and advantageous in our advancing evolution from what is accidental or inimical to it. Many eminent minds, indeed, are appalled at the temerity and the impatience of the more radical members of contemporary society in their manifestations of the prevailing spirit of inquiry. Traditions, customs, cherished beliefs and legal methods of procedure are all being challenged. In an era of unparalleled enlightenment so far as available knowledge is concerned we are frequently startled by the fact that there are yet numerous localities where intellectual darkness, if not abysmal ignorance, prevails. In an era of unequaled philanthropy and international amity there are nevertheless instances of wars whose atrocities beggar description, while national armaments which threaten national bankruptcy go forward unimpeded. Although the administration of justice was never on the whole so equitable and so merciful as at present, we are becoming deeply conscious that courts of law so often lead to injustice as to almost warrant the questionable extremes of the "referendum" and the "recall." Thus, also, it is becoming painfully evident that while statesmen and publicists were never so well equipped for their work as at present, they are still pushing political and oratorical methods absurdly far in trying to settle by their aid such complicated questions, for example, as those of tariffs and the diminishing purchasing capacity of the world's

monetary standards. Although there never was a time when men of merit received more ready recognition, there are yet those who would seek to divide the earnings and the savings of the industrious and the thrifty with the shiftless and the improvident. And while there never was a time when the rights and the opportunities accorded to women were so numerous and so universal, there are yet members of their sex who, reckless alike of property and life, would destroy laws which society has slowly and laboriously built up through ages of tentative effort and experiment.

This stupendous plexus of conflicting issues, this world-wide phantasm, one might say, of realizable and unrealizable ideas and ideals, may well be a source of despair to the enthusiastic philanthropist, to the hopeful humanist and to the pious religionist; for unless they take into account the secular extent of the time element involved and hence the painful slowness of the processes of evolution, they will not only fail to understand the issues in question, but will fail also to anticipate and to appreciate the improvements to which these issues will lead when fully wrought out. No one unacquainted with the essentials of the Darwinian theory and no one not animated by a patient and painstaking spirit of research can expect to gain anything better than a superficial view of the activities, aims and aspirations of contemporary life. The problems it presents are as much problems in biology, in anthropology and in all of the older branches of physical science, as they are problems in political economy and jurisprudence; although, strange as it may seem, we have hitherto held them to be, and may still expect them to be long commonly considered, problems belonging solely to the provinces of politics and religion. Out of this mixture of wisdom and unwisdom, out of this conflict of opinions of the masses and the

classes, and out of the hopes and the fears of a small minority of contemplative and constructive minds will come the advances to which a healthy optimism bids us look forward. But these advances may be rationally expected to come only slowly and falteringly, with many setbacks, and with direct benefits chiefly for our successors rather than for us; for biological science has taught us that the social organism works in general with extreme deliberation and works for the individual only as a relatively insignificant unit in his race.

And in keeping with this broader view of our relations to the larger part of the universe, the event we celebrate is especially noteworthy not so much by reason of its individuality as by reason of the type it represents and the trend of current thought it helps to express. For important as this center of research undoubtedly has been, and should long continue to be, to biological science in America, it is only one of numerous agencies for research now undergoing rejuvenation or now springing up in various parts of the world. The spirit of stolid conservatism and the spirit of reckless enquiry, alike inimical to the public welfare and to the progress of science, are being replaced in larger and larger degree by a spirit of patient investigation which seeks to substitute constructive for destructive work and to discover how the best interests of mankind may be secured under the inexorable restrictions imposed by that vastly larger part of the universe which we have hitherto so commonly and so blindly ignored. In this conscious effort to discover our relations to the environment in which we find ourselves and in this conscious recognition of the limitations of human existence and endeavor are to be found the most encouraging evidences of progress. We should guard carefully, however, against our instinctive tendencies to accept the widely popular fallacy that what we

call research is either novel or of recent origin. Research, as we now understand the word, means simply a systematic application of the methods of science. These methods are as old, certainly, as written history, and they have undergone a tedious and painful development. We may no longer think rationally of the achievements of men as appearing suddenly any more than we may think rationally of other phenomena occurring in violation of the principle of continuity. All such vagaries, though still too common, belong to the Homeric childhood of our race. Neither are these methods the exclusive property or tools of any class or classes of men. What is new with regard to them is an increasing assurance in their validity as a means of truthfully interpreting and hence controlling within determinable limits the conditions of existence on our planet.

But in addition to these generally favorable circumstances for the appreciation and for the promotion of research, circumstances far more propitious, probably, than at any earlier epoch in history, there are many collateral considerations which obviously demand our attention if we are to make good use of the enlarged opportunities now becoming available to us in increasing measure. Along with the extraordinary advances of science and its beneficent applications in the nineteenth century there has come also an equally extraordinary development of private and public confidence in those advances and hence a desire for liberal endowment of research by individuals and by governments. This has been the case in our country especially. Captains of industry, philanthropists and legislators have manifested a spirit of altruism and a degree of foresight quite without parallel in previous experience. An unprecedented amount of funds has recently become available for research, and

this amount appears destined to increase as time goes on. We are thus confronted, in America, at any rate, by a relatively new set of problems for men of science, problems in finance, in administration and in adjustment of mutually helpful relations between novel research establishments and organizations already extant in the fields of education and other forms of altruistic effort. It is to some of the requirements which these problems demand of us as specialists in the domain of science that this address is more particularly devoted. What are the needs of the times, what are our personal duties and responsibilities as workers in science, and how should we seek to forward the improvements essential to further the progress of our race? To these and to allied questions your attention is henceforth invited.

It would appear quite unnecessary before an audience of this kind to further define the meaning of the word research. But it may be instructive to consider for a moment how far the popular mind, and how far many disciplined minds, may depart from the meaning we attach to the term. We should never forget that the investigator lives usually in the presence of majorities which do not understand him and that progress is largely conditioned by these majorities. Thus, to journalists and to their readers it would seem that research is akin to necromancy and that its results are produced chiefly by witches of the male sex, otherwise designated in the polite literature of our day as wizards. Closely akin to this infantile fallacy is the more subtle error entertained by a majority, perhaps, of our highly educated contemporaries, that the more remarkable results of research are produced not by the better balanced minds, but by aberrant types of mind popularly designated by that word of ghostly, if not ghastly, implications,

namely, "genius." Out of these misconceptions, which require only the briefest examination for their rejection, arise volumes of fruitless correspondence and many directly serious obstacles to progress. They are evidently part of the intellectual rubbish we have inherited from the remote past; but unfortunately their obvious origin does not prevent well disposed inquirers from raising the questions whether research establishments will undertake investigations which are not scientific and whether they should not give special attention to eccentric rather than to normal minds. A clarification of ideas which will lead to a dissipation of these vagaries is one of the greatest needs of the day.

A similar clarification of ideas in the popular mind is essential to appreciate the distinction between the usual aims of the investigator and the usual aims of the inventor. Investigation and invention are so closely allied that they are often confounded with one another. Indeed, the investigator is often compelled to devise inventions to promote his researches and the inventor is often compelled to make investigations in order to perfect his inventions; while the secretiveness of the inventor has its correlative in the desire of the investigator to secure priority of publication, as in the naming of new species. But in general the objects of the investigator are mainly altruistic while those of the inventor are mainly egoistic; the one seeks to give freely to the world the results of his researches, the other seeks personal benefits by aid of letters-patent. It is plain, therefore, that while there is now room for contemporaneous and probably advantageous public altruistic and private egoistic organizations for the promotion of research, relations of complete reciprocity can not obtain between them. Thus, for example, the U. S. Bureau of Standards is giving the results

of its admirable researches to a multitude of highly productive and praiseworthy commercial organizations; but whether the inventions so promoted and protected by patent laws will result on the whole advantageously to society or to inventors is a question which remains to be determined. It is well known that as a rule inventors are a sadly disappointed class; and when we consider the great waste of effort and resources entailed by patent litigation, it appears plain that the aggregate of rewards arising from the egoism of the inventor is much less than the aggregate of rewards arising from the altruism of the investigator. We may look forward, perhaps, to an epoch of more advanced social development when the functions of patent offices will be abolished except as they may serve to register important improvements and discoveries. In the meantime, altruistic research agencies may not be properly expected to perfect inventions, to secure letters-patent for them, to defend inventors in suits at law or to exploit successful inventions.²

Another popular illusion which everywhere retards the evolution of research institutions is more specious and hence more dangerous than those just referred to. It involves all of the fallacies which have thus far rendered the highly developed mathematical theory of probabilities of limited application in the ordinary affairs of life. It manifests itself in various forms, but most commonly finds expression in the notion that research establishments should solicit suggestions; or busy themselves in

casting drag-nets in the wide world of thought, or in dredging, as biologists would say, with the expectation that out of the vast slimy miscellanies thus collected there will be found by the aid of a corps of patient examiners some precious sediments of truth. By this method it is assumed that the entire range of possibilities for discovery will be included; and it is likewise assumed that no idea of value can escape the superhuman intelligence attributed to the examiners. There is thus available at last, the argument runs, a comprehensive way to utilize for any given case even the small soul of truth contained in that ancient and cautiously wise aphorism, "there may be something in it"; and the doors are thus opened also to the hosts of amateurs, dilettanti and paradoxers who stand ready to waste the time and the resources of research establishments in the pursuit of the obvious, the futile and the demonstrably unattainable.³ Two simple facts will suffice to dispel this illusion. The first of these is that important advances in knowledge are far more likely to issue from the expert than from the inexpert in research. Indeed, the probability of extending knowledge by organizations conducted by disciplined investigators is so much greater than the probability of extending knowledge by the drag-net method that we not only may but should ignore the latter in comparison with the former. The second fact is that no competent examiner is willing to spend his energies in raking over the

² There is little doubt that an endowed organization, and possibly a state organization, for the promotion of inventions, could now be established with great advantage alike to society and to inventors. There are plenty of able inventors who would be glad to work on salaries and to give as freely to society the results of their labors as investigators do.

³ Along with the amateurs and the dilettanti, who are not without certain commendable characteristics, there are to be counted also in great numbers cranks, quacks, charlatans, aliens and mountebanks. The paradoxers include especially are-trisectors, circle-squarers and perpetual-motion men and women. It is amazing how easy it is for an individual of any of these classes to get letters of introduction to research establishments from our otherwise highly esteemed contemporaries.

contents of the drag-net. No more fruitless or thankless task could be assigned to an expert investigator than that of detecting the relatively microscopic quantity of truth to be found in the vast volume of error with which undisciplined minds would eagerly occupy his attention.

But the need of clear ideas on the subject of research is not limited to the majorities of our fellow men who are naturally preoccupied with other affairs. There are vexatious variations of opinion as to what research is, and great diversities of view as to how it may be effectively carried on, held even by its devotees and more especially by its nearest allies in the fields of education. Thus, adventure, exploration, the collection and naming of specimens and the tabulation of bibliographies, any or all of which may be incident to, are not infrequently mistaken for research by those engaged therein or seeking to contribute thereto. Similarly, it is often assumed that research is a harmless and a fruitless diversion in the business of education, and that it requires but a portion of the leisure time of those chiefly occupied with duties of instruction and administration in colleges and universities. On the other hand, some eminent minds maintain that serious and fruitful research can be advantageously pursued only in connection with work of instruction, while a few enthusiasts go so far as to suggest that the mental and the bodily vigor of an investigator can be conserved only in the stimulating presence of immature minds, otherwise known as students or candidates for higher academic degrees. Such eminent minds and enthusiasts entertain grave doubts as to the propriety of the existence independently of colleges and universities of research establishments. It is darkly hinted, indeed, that the latter may work harm, if not ruin, to the former by enticing

the effective teacher away from his students and by checking the diffusion in order to promote the advancement of knowledge. Thus it has happened that sinister predictions and panicky sentiments have attended the development of a few research establishments in our own country and abroad during the past decade. We seem to have undergone a sort of intellectual flutter similar in many respects to that more profound emotional disturbance which followed the publication of the ideas of Darwin, Wallace and Spencer, a half century ago, and presaged the extraordinary development of biological science as we know it to-day.

Happily, the untoward features of this more recent agitation, features leading to numerous unrealizable ideals and to numerous necessary disappointments, are now subsiding; and the sense of humor and the sense of proportion so essential to the dissipation of mental aberrations are now regaining the ascendancy. Indeed, after a decade of wild conjecture and extravagant expectation on the part of many men of science and many educators, we may now venture, perhaps, to look squarely at the facts which confront us and to apply the rules of elementary arithmetic with some hope of adequately visualizing the relations which should exist between educational establishments, on the one hand, and research organization, on the other.

Confining attention to our own country, some of the salient facts and figures we need to contrast and to contemplate are the following:

The number of higher, or degree-giving, establishments in the United States is now upwards of six hundred; the aggregate annual income of these is upwards of one hundred millions of dollars; and the number of officials connected with them is upwards of thirty thousand.

On the other hand, the number of independent research organizations in the United States is less than half a dozen; their aggregate annual income is less than two million dollars; and the number of officials primarily connected with them is less than five hundred.

The overwhelming disparity between these figures should assure us that there is no immediate and no prospective danger of the usurpation on the part of the more recent research organizations of the rights, privileges and immunities so long, and in the main so justly, enjoyed by educational establishments. But these arithmetical data go further and serve to dispel other illusions which have much hindered the progress of research during the past decade. They show at a glance why the combined incomes of a few research institutions could not meet the deficiencies even of their nearest allies, to say nothing of meeting the limitless wants of numerous other establishments which have expected likewise to be supplied from the same source. It is probable, of course, that of the large aggregate income of our higher educational institutions only a small fraction is available for the promotion of research. This must certainly be the case if the vast amount of expert testimony available is to be taken at its face value. But here again there appear some obscurities that need clearing up. For, as already indicated, it is claimed by many of our highly esteemed academic colleagues that colleges and universities are not only specially qualified and equipped for the conduct of investigation, but that they are the real ancestral homes of this high calling. They seem to possess all of the desiderata except funds. They are like the farmer who has an abundance of fertile land, but who remains inactive because he lacks capital for the production of crops. And just as we would esteem it

permissible to challenge any claim on the part of our farmer that he is an expert in husbandry and that his farm is a natural agricultural experiment station, so must we regard it permissible, if not highly desirable in the interests of progress, to question the claims of our academic colleagues. The simple truth seems to be that research has been and is still rarely regarded by the great majority of academic men and women as anything but an unimportant incident to the principal business of academic life. This principal business is the transmission from generation to generation of acquired learning; and it has been adhered to so generally and so rigorously in the past that until our own time educational institutions might be said, with only slight qualifications, to have been depositories of stationary thought. Moreover, in these days of decreasing pretensions and increasing fulfillments it is incumbent especially on those claiming superior qualifications and facilities for research to bestir themselves in order that they may secure that degree of independence which is indispensable to the effective pursuit of fruitful investigations. It is futile as well as incoherent to argue that the funds of the newer organizations could be better applied by the older ones, since we have not heard of the latter proposing to divide their incomes with the financially embarrassed, but often highly commendable, smaller colleges of the country. But in addition to this patent inconsistency on the part of the protestants there is an obvious and insuperable arithmetical obstacle in the way of an acceptable division of the incomes of a few research organizations amongst a multitude of educational establishments, however worthy and however selected.

All this leads up to a frank submission of the proposition that whatever may prove to be the working relations between research

organizations and educational institutions, they must be relations of reciprocity. This is a proposition which should be of special interest to your organization, since sooner or later you will be compelled to consider it. Trustees of such organizations, it is safe to predict, will not be disposed to surrender their rights or to delegate their duties. In this respect they will doubtless be found to be just like trustees of educational institutions. Biologically the two groups belong to the same genus if not to the same species, and under like circumstances the reactions of either group will be the same as those of the other. And is it not plain that such relations of reciprocity are the only permanently satisfactory relations attainable? The widely spread, if not prevalent, assumption that research establishments are mere disbursing agencies, waiting for suggestions of appropriate ways in which to apply funds, is creditable neither to those who entertain it nor to establishments which accept it. This assumption entails too readily the futilities of amateurism, the dangers of favoritism and all of the inefficiencies due to division of responsibilities and to scattering of resources. Thus, while it is quite true that a majority of the fundamental researches of the past have been accomplished by individuals and that they will continue to be so accomplished in the future, it should nevertheless be the primary purpose of a research institution to institute and to conduct research; to take up especially those larger problems not likely to be solved under other auspices, problems requiring a degree of organized effort and a continuity of purpose surpassing in general the scope and the span of life of any individual investigator. Such institutions, like colleges and universities, should expect to continue their work forever, or, at any rate, so long as

they are able to add to the sum of that sort of knowledge which is verifiable and hence permanently useful to mankind.

But "how," it is often asked, and doubtless some of our colleagues here are now raising the query, "are the requirements of the worthy individual investigators in colleges and universities to be supplied?" To understand and to answer this question rationally we need first to learn how to distinguish endowments from incomes and then to appeal to our knowledge of mental arithmetic. An application of this much-neglected branch of an ancient science will quickly show that the income of no single research institution now extant, or likely to be founded, can come anywhere near meeting the wants of the great army of competent investigators now pressing for financial assistance to forward their researches. Indeed, neither in a single institution nor in all of those now existing combined, nor in a score more of such, will there be found sufficient funds to supply the world-wide and rapidly growing demand for them. When we are ready to appreciate these salient numerical facts we shall be able to make the next step essential to relieve at once the straitened conditions under which hosts of worthy investigators are now chafing and to respond more quickly to the urgent demands of society for obviously attainable and desirable improvements dependent on research. This next step should consist, first, in an appeal not solely to a few of the captains of industry and the philanthropists whose wisdom and benevolence have been so conspicuously manifest in our day, but to the entire class of such, whose aggregate number, as long since proved by the experience of charitable, educational and religious organizations, is legion. If a small fraction of the vast aggregate annual expenditures of such organizations were devoted to research

under competent guidance, it would go far towards an understanding and hence an amelioration of the adverse social conditions which have so long roused the sympathies but baffled the judgments of the majorities of our fellow men. And in respect to this appeal it is a most encouraging fact that there are in waiting, so to speak, everywhere in our country, at least, increasing numbers of intelligent men and women ready to endow research as soon as they can find trustees of research funds in whom confidence may be safely reposed.

Secondly, this step in line towards relief should consist in the development of larger opportunities for research and in the collection of corresponding endowments therefor, by universities. They must lose their leadership in research if they are obliged in any considerable degree to depend on other organizations for financial support. They should recognize that the ends of research are not limited to the highly worthy object of fitting candidates for the doctorate degree; and they should recognize that there is the amplest room for the simultaneous existence of educational institutions along with other organizations whose primary purpose is not the diffusion but the enlargement of learning. And in the adjustments now forming between these two classes of establishments there should arise the freest relations of reciprocity, especially as regards individual investigators. Much baseless fear has been expressed lest a few research organizations should rob academic staffs of their ablest men, as if those relations at first slightly unilateral might become increasingly or wholly so. It is of supreme importance to both classes of establishments, and particularly to progress in the immediate future, that eminent men should be free to pass from one to another of these establishments without encountering any administrative or other purely in-

stitutional obstacles. In fact, it should be esteemed one of the highest attainable objects of any institution to assist in the production of investigators whom other institutions are glad to offer desirable or superior opportunities.

And thirdly, relief should come in large measure through increasing appropriations of public funds to forward all of those numerous researches essential to the public welfare. These fall mostly in the fields of applied science and are often erroneously assumed to produce only the so-called "practical results" directly aimed at. But every investigator knows that the by-products of such researches are usually quite as important as, and often more important than, their anticipated products. A vast aggregate of such work is now carried on by the United States government, by states and by municipalities; and it should be observed that on the whole this work is well done, in spite of the contemptuous references one sees and hears occasionally to the conduct of scientific work under governmental auspices. In a republic destructive criticism of this sort has little weight, since it carries with it the illogical conclusion that our governors are, as a class, inferior to the citizens who elect them. What we much need in this, as in many allied governmental affairs, is less of destructive criticism founded on the shifting sands of partisan sentiments and more of constructive criticism founded on adequate knowledge of biology and anthropology. As a matter of fact and of justice it must be admitted that the aggregate of high-class work of research accomplished by the bureaus of the United States government in recent decades compares very favorably with the corresponding aggregate accomplished by educational and other establishments of our country during the same period. We who labor in the latter establishments, therefore, have no ade-

quate reason to suppose that our reputations may be much improved by invidious reflections on the methods in science followed by men who happen to live "in Washington." Here again it is useful to remember that we and they belong to the same species.

But in order that any measures of relief and of response to the pressing demands of society may become adequately and progressively effective, certain other requirements of greater importance must be realized. These requirements must be supplied chiefly by men of science. To a far greater extent than ever before the methods and the applications of science are concerned with the daily affairs of domestic, national and international life. Ours is an era of unequalled opportunities in science; but it remains in part, at least, to be demonstrated whether the types of men called scientists, whom it has taken many generations to evolve, are prepared to meet the responsibilities as well as the duties now falling upon them. It is an open secret that as a class doctors in science are on trial, and properly so, in so far as they may suggest remedies for the body politic. In the evolution of society they are a sort of "fourth estate" and the latest in the order of human development. It is not so long ago, quite within the recollection of some here present, when society was guided almost wholly by three other classes typified by the man in the saddle, by the man in the pulpit, and by the man on the bench. The rôle of the man of science as manifested somewhat sensationally to the popular mind, for example, in the conduct of industries, in the control of epidemics and in the construction of the Panama Canal, has been recognized only recently as one of vital importance to communities and to states. It is especially incumbent on us, therefore, at this juncture, to put our scientific houses in order and to

be ready to demonstrate the validity of whatever claims we may set up by the production of work which will stand on a basis of verifiable merit. It would be unscientific, and inimical to progress, to ask for easier conditions of entrance into the world's affairs, from which as a class we may no longer advantageously either hold ourselves aloof or be debarred by other classes.

Fortunately, there is now little danger that the prejudice and the ignorance which provoked so many wordy wars and so long contested the advent of the "fourth estate," will exert anything like such sinister influences in the future as they have exerted in the past. Science is ever ready and willing to settle matters in dispute by the arbitrament of demonstration, and the conclusiveness as well as the fairness of this procedure is now nearly universally conceded. Indeed, the effectiveness of the methods of science is now not only generally recognized within each of the older "estates" just referred to, but even the more conservative members therein are making and projecting scientific researches with a degree of enthusiasm which compels our admiration. The dangers which beset us are rather dangers of popular over-confidence in our methods, of amateurism and dilettantism and of premature generalizations. The prevailing optimism needs to be chastened by the reflection that the millennium is not in sight, that sound research means arduous enterprise and that advances in knowledge come, as a rule, only after prolonged and even painful effort. In the meantime, while guarding carefully against these dangers, it is the part of wisdom to take every legitimate advantage of the present highly favorable attitude of our contemporaries towards research. We of the "fourth estate" need especially to fraternize with our colleagues

of the other three "estates" and likewise with the still larger and equally favorably disposed groups of our contemporaries in the world of trade, commerce and industry. It is well for us to study them lest we should misunderstand them. We need their aid now more than they need ours; and it should be borne in mind that when any proposition is to be voted upon they are overwhelmingly more numerous.

Time does not permit more than passing reference to the important but as yet little studied subject of research publications, their proper distribution and their adequate popularization; nor to the more important, though less debatable, subject of administration, including what are too often contemptuously regarded by men of science as unattractive if not unessential details of fiscal business; nor to the still more important and complex but little understood subject of boards of trustees, the best methods of choosing them and their proper relations to research organizations.* It must suffice here to call attention to them, among many other subjects, as specially in need of patient investigation by men of science. They are subjects, however, whose elucidation may be deferred. An adequate understanding of them will come, apparently, only after the more elementary considerations already dwelt upon are visualized and appreciated. Passing these considerations rapidly in review, the salient needs of research and some of their numerous corollaries may be advantageously

* An important contribution to this subject has been made by President Eliot in his volume on University Administration (Houghton Mifflin Company, 1908). All such works, however, are generally held to be "too theoretical" by the average man who prides himself on being "practical." In his assumed freedom from theory he often adopts the obviously erroneous theory that there is no room for progress or improvement in the conduct of such affairs.

summarized in paraphrase and in aphorism even at the risk of apparent dogmatism:

We need first to recognize that in its inclusive aspects research is in scope coextensive with the universe of which we form an insignificant part, but in which we are obliged to play the significant rôle of interpreters if we would make the best of our opportunities. The experience of our race has demonstrated that by study and hence by understanding of this universe the roads to progress may be found. The methods of research are the methods of science. They are not of recent origin. They have undergone an evolution extending far backwards towards the era of primitive man. What is new about them is a widely general and rapidly increasing recognition of them as the most trustworthy methods man has devised for the discovery of truth and for the eradication of error. Along with this recognition there has gone on, and is still going on, a gradual elimination of Homeric illusions and fallacies; so that male as well as female witches must be abandoned by all except the more atavistic, while the appellation "genius" in the singular as well as in the plural is becoming one of doubtful compliment. We are coming to understand also that while there may occur flashes of wit, and even of wisdom, from abnormal types of mind, the more effective emanations of both wit and wisdom are to be expected from normal and patiently contemplative types. And thus the more striking results of research, quite commonly in the past attributed to wizards and to genii, and still so attributed by a majority, probably, of contemporary writers for the popular press, are now understood by the thoughtful to be products rather of industry, sanity and prolonged labor than of any superhuman faculties.

Out of this rational appreciation of the methods of science have arisen quite natu-

rally, but relatively suddenly, unprecedented demands for research, on the one hand from communities and states, and on the other hand from academies, societies, institutes and universities. We should observe, however, that this intellectual uprising dates back at least a half century, to about the time when your science was emerging from the limbo of "natural history" in which it had been left to slumber by Pliny the elder. It is part of the general uprising of the nineteenth century of which the multiplication and fruitful activity of scientific societies in America is another surprising and gratifying manifestation. Quite naturally, also, along with this greatly enlarged appreciation of the value and desirability of research there has come a corresponding demand for enlarged facilities and particularly for funds. This demand, like most unanticipated demands, is in the aggregate vastly greater than the present or possible supply, but not greater than can be met if pruned of its adventitious appendages. Research and research organizations are somewhat in danger of being swamped by an excess of symbiosis.

In these circumstances there is constant need of the caution and the deliberation which distinguish scientific investigation from impulsive and emotional mental conduct. We should frequently recall that the characteristic defect even of deliberative bodies is lack of deliberation. We need constantly to apply our well-known methods of research to the questions confronting us. Instead of following precedent, we should in general avoid it. When, for example, a research fund is established we should not make haste in academic fashion to set up poor-boy scholarships and roving fellowships to be awarded to the amateur and to the tyro, but we should seek to originate and to conduct research under the auspices of competent and responsible investigators.

And as regards research in academic circles, we need to fix attention rather on the professors who are qualified to extend the boundaries of knowledge than on their pupils. These latter, if worthy of the name, will require little formal instruction in the presence of evolving discoveries and advances; moreover, they must learn early to think with their own heads if they may hope to become either competent teachers or leaders in work of research.

And finally, men of science, if they are to meet the requirements now demanded of them, need more of contact with, experience in and sympathy for, ordinary business life. We are as a class of too recent monastic descent to fit comfortably in our present social environment. The man of affairs does not understand us, and hence often looks upon us with suspicion or even with contempt. He is generally sure that the man of science can know little of finance and of other affairs vaguely emphasized by the adjective "practical." Argument concerning this matter is idle in the face of existing conditions which determine majorities in boards of trustees and in legislative assemblies. Nor would it be the part of wisdom to change abruptly if we could the present course of evolution in affairs of administration. We need to accept the situation as we find it and to qualify for gradual entrance into, and participation in, the details of this ordinary life. It will not be taken for granted, for example, that we can keep accounts and live within income, but a positive demonstration will be accepted without protest. It may be easily shown to our satisfaction by *a priori* reasoning that men of science are no more likely to wreck corporations than financiers, general managers or promoters, but proof by numerous concrete examples must be forthcoming from us. And in proving capacity for trustworthiness in these, to us,

new fields we should avoid the manifest errors of our business predecessors. Agreeing with Dr. Johnson's astronomer that "the memory of mischief is no desirable fame," we should not seek, for example, to perform the academic feat of capitalizing deficits. Even if there were a body of alumni to which appeal might be made in distress, such a feat would be unworthy of a research organization. Above all, research organizations should embrace the great advantages that come from open audit and truthful publicity in all financial affairs. We should accept these and the other conditions and limitations of our environment to which attention has been called, not in a spirit of unreflective meekness, nor in a spirit of impatient defiance, but in a spirit of philosophic equanimity, confident that the scientific methods of observation, experiment, comparison, demonstration, generalization and verification will ultimately work out adjustments to the permanent advantage of our successors, if not to the ephemeral advantage of ourselves.

R. S. WOODWARD

*ADDRESSES AT THE DEDICATION OF THE
NEW BUILDINGS OF THE MARINE
BIOLOGICAL LABORATORY¹*

THE subject of biology possesses immense significance for human thought and action. If the biology, the sociology, the philosophy and whole mode of thought of the twentieth century differ quite radically from those of the mid-nineteenth century, it is largely because the biological investigations of Lamarck, of Darwin and of many others founded the evo-

lution theory, the future development of which is one of the main problems of biology.

The cell-theory, another great generalization of biology, revolutionized the study of pathology, the basis of medicine, besides furnishing the indispensable foundation for all future biological studies. The conception of the physico-chemical constitution of protoplasm, or living matter, is a third great contribution of biological science of inestimable significance for science and philosophy.

Biology is related to the most practical affairs of life: to medicine, of which it forms the indispensable foundation, to hygiene and public health, to many problems of agriculture and animal industry, and to fisheries problems. Economic entomology, parasitology, protozoology, etc., are practical branches of our great subject; not to mention the fundamental principles of the mooted subject of eugenics. The advancement of biology is one of the most important considerations of modern society.

Even such an intentionally incomplete statement of the significance of biology may appear exaggerated. But nothing is more sure than that the acquisition of knowledge increases man's control of nature, and that the science of biology, although still in an early stage of its development, promises control of those uncertainties of practical human life which are most perplexing and dangerous to the race.

The significance of the present occasion is to be found only partly in such general considerations. This laboratory represents one of the forces that have to be reckoned with in this general situation. But it is to the special significance of this occasion that I would more particularly direct your attention.

The sea-shore is undoubtedly the ideal situation for a biological station, because marine life offers certain valuable opportunities for study that are unique. These are given in such a situation as ours, and we relinquish none of the opportunities of inland laboratories. Louis Agassiz, in America, and Anton Dohrn, in Europe, were among the first to organize seaside laboratories; about the same time, 1872, Agassiz founded his station on the

¹ In addition to these shorter addresses and the address of Dr. R. S. Woodward, printed above, an address was made by Professor Edwin G. Conklin, of Princeton University, who, on account of his absence from the country, was unable to prepare it for publication. Mr. C. R. Crane, president of the board of trustees and donor of the building, presided and presented the speakers.